PRISM SOLUTIONS

RESEARCH BRIEF

Research Request:

Bird Strike Mitigation Techniques for Pilots and Airports

Research Response:

Bird Strike General Info

In the United States, a list of birds most hazardous to flight has been identified:

- large flocking waterfowl (Canada goose);
- gulls;
- Pigeons/doves;
- blackbirds,
- Starlings/sparrows; and
- raptors (hawks and kestrels).

A number of widespread misconceptions about bird strikes may give pilots a false sense of security and prevent them from reacting appropriately to the threat of a bird strike or an actual event. These misconceptions include:

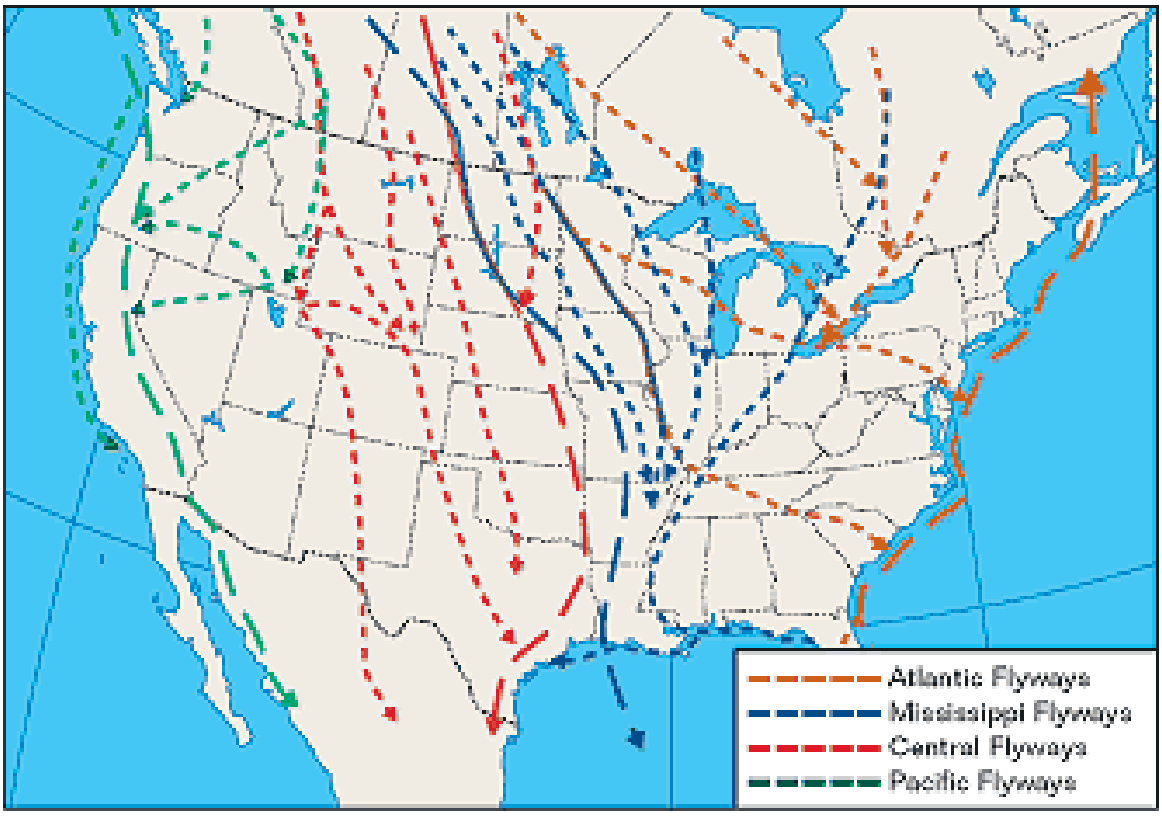
- Birds don't fly at night.
- Birds don't fly in poor visibility, such as in clouds, fog, rain, or snow.
- Birds can detect airplane landing lights and weather radar and avoid the airplane.
- Airplane colors and jet engine spinner markings help to repel birds.
- Birds seek to avoid airplanes because of aerodynamic and engine noise.
- Birds dive to avoid an approaching airplane.

In fact, none of these statements is scientifically proven.

Bird Strike General Info Cont...

Birds migrate between the months of July and November, with the peak being in September. It is also important to be familiar with the patterns of migratory birds. There are four major migration routes across the United States. These routes are:

- The Atlantic Flyway, which follows the Atlantic Coast.
- The Mississippi Flyway, which is in and around the Great Lakes and the Mississippi River.
- The Central Flyway, which is situated east of the Rocky Mountains.
- The Pacific Flyway, which follows the West Coast.



There is a variety of existing and new technologies available, such as Avian Radar, to predict and detect birds potentially hazardous to aircraft operations and provide information to reduce the risk of these hazards. Such technologies and procedures are particularly important in dealing with the significant hazards posed by birds beyond the boundaries of airports.

Bird Strike Mitigation Techniques for Pilots

About 90 percent of bird strikes take place at or near airports, usually during taking off or landing. Although it is not possible to avoid all bird strikes, flight crews can take steps to reduce the chance of a bird-strike event. If a bird strike does occur, the appropriate action can improve the flight crew's ability to maintain control of the airplane and land safely.

PREVENTION STRATEGIES

- ⇒ Pilots should **not** rely on onboard weather radar, landing lights, airplane markings, time of day, or visibility to prevent bird strikes.
    - ⇒ Aircraft weather radar are not effective as a means of warning birds; they do not sense the low power emissions and frequencies of these units.
- ⇒ If possible, avoid areas in which there is a known risk.
- ⇒ If large birds or flocks of birds are reported or observed near the runway, the flight crew should consider:
    - ⇒ Delaying the takeoff or landing when fuel permits. Advise the tower and wait for airport action before continuing.
    - ⇒ Take off or land on another runway that is free of bird activity, if available.
- ⇒ Flight operations may need to be modified in the presence of known or anticipated bird activity.
- ⇒ Avoid or minimize maneuvering at low altitude to avoid birds.
- ⇒ Avoid flying beneath a flock of birds
    - ⇒ When birds sense danger in the air they have a tendency to dive.
- ⇒ If you are approaching a bird you should pitch up.
- ⇒ Try to avoid areas such as marshlands and landfills as birds like to congregate near them.

Pre-start

- ⇒ If the weather is cool, warm the windshield to reduce the chances of it shattering if a bird were to hit.
    - ⇒ Also consider keeping shatterproof glasses/goggles on hand to wear when taking off or landing in areas with birds.
- ⇒ Prior to engine start, review emergency procedures pertinent to your aircraft type and operation. Pay particular attention to rejected-takeoff and engine-failure procedures.

Bird Strike Mitigation Techniques for Pilots Cont...

Taxiing for Takeoff

⇒ Be alert while taxiing for takeoff and note any bird and mammal activity reports by ATS providers and other operators.

⇒ While taxiing, report wildlife activity observed on ramps, taxiways, and runways to ATS providers, UNICOM, and other aircraft.

⇒ Be especially vigilant when operating at airports that either do not have ATS providers or have limited hours of ATS operation. Often, these airports have no formal wildlife monitoring or management.

⇒ Prior to takeoff, it may be necessary to back-taxi the length of the active runway to ensure that there are no birds or mammals.

Takeoff

⇒ Be aware of conditions that may affect your ability to either reject the takeoff or continue flying under reduced aircraft performance.

⇒ Before commencing takeoff, check the runway once more for wildlife; many birds stand on concrete and asphalt surfaces to warm themselves and to gain a clear view of any approaching predators.

⇒ Be aware that an aircraft taking off in front of you may frighten birds and mammals into your flight path.

⇒ If there is bird activity on the runway, be prepared to wait for wildlife management personnel to clear the birds. If traffic and weather conditions permit, use another runway. Wildlife hazards should be treated like any other flight safety hazard—if any doubt exists concerning safety, delay your takeoff until conditions are right.

⇒ Use landing lights during takeoff. Although there is no conclusive evidence that birds see and avoid aircraft lights, limited data and anecdotal evidence suggest landing lights—particularly pulsed landing lights—make the aircraft more visible to birds and provide more time for the animals to avoid the aircraft. However, birds on the ground tend to face into the wind. They will probably have their backs toward you as you are taking off. If startled, the flock may take off and fly directly into your path.

⇒ Select engine ignition “on” for takeoff to enhance engine flameout protection when operating turbine-powered aircraft in the presence of birds.

⇒ Should a bird or mammal strike occur during the takeoff roll, a rejected takeoff is the safest course of action when prevailing conditions are appropriate. When safe, vacate the runway and shut down aircraft engines. Before continuing the flight, have the aircraft thoroughly inspected, preferably by an aircraft maintenance engineer (AME).

Bird Strike Mitigation Techniques for Pilots Cont...

Climb-Out

⇒ Be prepared to adjust your climb route to avoid birds.

⇒ The best way to reduce the probability of a bird strike is to maximize rate of climb on departure. [Pilots of] jet aircraft should use the ICAO Vertical Noise Abatement Profile 'A' (VNAP 'A'). The benefits are:

  ⇒ low aircraft speed (V2 + 10), which reduces impact force. The most effective way to reduce the severity of a bird strike is to reduce speed. Bird-impact force increases as the square of speed; doubling speed increases the impact force by a factor of four;

  ⇒ rapid climb rate to get above where most bird strikes occur (below 3,000 ft. AGL) as quickly as possible; and, climb-out occurs as close to the airport boundary as possible, where bird activity is managed.

  [*Note:* Pilots should consider that an increased deck angle that results from a steeper climb may make it more difficult to see and avoid birds.] •

⇒ If there is an altitude band where birds are anticipated, climb through these altitudes as quickly as possible, using the manufacturer's recommended best rate of climb speed.

⇒ The majority of bird strikes occur below 10,000 ft AGL, so continue to use landing lights during climb until above this altitude.

⇒ Use extreme caution if accelerating above 250 knots below 10,000 feet ASL. In Canada and some other countries, aircraft may accelerate above 250 knots above 3,000 feet AGL. This increases the probability of a bird strike, since climb rate is reduced while accelerating, thereby increasing time spent in altitudes where birds are more likely to be present. The potential severity of a strike also rises, since impact force increases. Bird strikes above 3,000 feet AGL occur less frequently, but the majority of these strikes involve larger birds and incur frequent and significant damage.

En Route

⇒ Listen to the appropriate en route radio frequencies to obtain up-to-date information on bird activity from ATS providers and other aircraft.

⇒ Report all hazardous bird movements to ATS providers and other aircraft.

Approach and Landing

⇒ Approach and landing is a critical phase of flight. Strike statistics show that 39% of bird strikes and 58% of mammal strikes occur during approach and landing.

Bird Strike Mitigation Techniques for Pilots Cont...

⇒ Obtain the latest bird and mammal activity information from ATS providers, ATIS, UNICOM, and other aircraft.

⇒ Be especially vigilant when operating at airports which either do not have ATS providers or have limited hours of ATS operation. While these airports often do not feature wildlife monitoring and management, it is nonetheless prudent to request that airport personnel inspect the runway environment to ensure it is clear of hazardous wildlife. Watch for wildlife activity throughout approach and landing.

⇒ Plan your descent and approach route to avoid areas that attract birds.

⇒ During descent and approach in areas with high bird activity, reduce airspeed to diminish the severity of potential bird strikes.

⇒ Avoid extended low-altitude level flight, particularly over water courses, nature reserves, or other areas of known or expected bird activity.

⇒ If bird activity is reported at particular altitudes, use a higher rate of descent— without increasing speed—to minimize exposure to potential bird strikes.

⇒ Wildlife hazards during approach and landing should be treated like any other flight safety hazard—if any doubt exists concerning safety, delay your landing until conditions are right.

⇒ Be extremely vigilant if birds are reported on final approach. If birds are expected on final approach, plan additional landing distance to account for the possibility of no thrust reverser use if a bird strike occurs.

⇒ If birds are encountered on the approach, consider a go-around and a second approach, but only if the go-around can be initiated without striking birds after power is increased. This strategy may allow the birds to disperse before your return. Please note that several bird-related incidents and fatal accidents have resulted from pilots initiating a go-around when the aircraft was in a low energy state and likely capable of a safe landing.

⇒ When landing is assured, consider landing through birds versus a missed approach to avoid birds. This reduces the energy of the collision, the potential for increased damage associated with engines at a high power level, and the potential for multiple engine ingestions at low airplane energy states and low altitude.

⇒ Use landing lights during approach and landing to make the aircraft more visible to birds.

⇒ If you encounter birds or mammals, be sure to report this activity to ATS providers, UNICOM, and other aircraft.

Bird Strike Mitigation Techniques for Pilots Cont...

BIRD STRIKES DURING TAKEOFF ROLL

If a bird strike occurs during takeoff, the decision to continue or reject the takeoff is made using the criteria found in the Rejected Takeoff maneuver of the QRH. If a bird strike occurs above 80 knots and prior to V1, and there is no immediate evidence of engine failure (e.g., failure, fire, power loss, or surge/stall), the preferred option is to continue with the takeoff followed by an immediate return, if required.

DETECTING A BIRD STRIKE WHILE IN FLIGHT

- Visual: Birds seen in close proximity to the airplane or colliding with the airplane, bird remains on windshield, cracked windshield.
- Tactile: Vibration of airframe or engine, thrust loss, asymmetric thrust, increased drag, abnormal airplane handling characteristics.
- Auditory: Noise of strike or noise attributed to resulting damage: engine surging, compressor stalls, aerodynamic noise from damaged radome, loss of pressurization from pressure vessel penetration.
- Olfactory: Smoke, odor, or cooked bird smell.
- Engine indications: Reduction or fluctuation in primary power parameter (e.g., engine pressure ratio, fan speed, or equivalent), abnormal fuel flow, abnormal engine vibration monitoring (e.g., error vector magnitude or equivalent), engine failure, engine exceedances.
- Flight instruments: Loss of data or erroneous indications arising from damage to air data sensors or angle-of-attack sensors.
- Other airplane systems or structure affected directly by a strike: Damaged communications or navigation antennas, damage to exposed electrical wiring or hydraulic lines, damaged radome or weather radar, broken landing lights, or cascading and multiple effects from sensor damage or engine damage.

If you are flying in an area with known bird hazards, make sure that you have an emergency plan in case of a bird strike. Consider each of the phases of flight and know what you would do in each phase. Would you go around? Abort a takeoff? If enroute, could you make it to an airport or would you need to make an emergency landing and, if so, where?

RESPONSES TO A KNOWN OR SUSPECTED BIRD STRIKE

If you are involved in a bird strike, regain control of the aircraft before doing anything else. Keep in mind that if the airfoils are damaged, the stall speed may increase and maneuverability may decrease. Most importantly, fly the aircraft.

Bird Strike Mitigation Techniques for Pilots Cont...

Immediate action

- Fly the airplane and maintain flight path control.
- Monitor flight and engine instruments.

Multiple engine failure or thrust loss

- Attempt to restart engine(s).

Severe engine damage

- Shut down engine according to procedure.

Strong engine vibration

- Reduce thrust, which will often reduce vibration.
- Shut down engine per flight crew operations manuals guidance.

Multiple engine ingestion and abnormal engine indications

- Air turnback or diversion to nearest suitable airport.

Known or suspected multiple engine ingestion, with normal engine indications

- Consider air turnback or diversion to nearest suitable airport.
- Reevaluate decision to continue with extended-range twin-engine operational performance standards, extended range operations, or overwater flight because engine damage or performance degradation may manifest later in the flight.

Known or suspected strikes with large flocking birds, such as Canada geese

- Consider air turnback or diversion to nearest suitable airport, because damage may affect aerodynamic lift and drag, subsequent fuel burn, and ability to complete the flight safely.

Known or suspected airframe damage or engine damage

- Maintain or reduce speed — do not accelerate unless necessary for safety of flight or to maintain flight path control.

Bird Strike Mitigation Techniques for Pilots Cont...

Damaged windshield or depressurization

- Below 10,000 feet, discontinue climb and level off.
- Above 10,000 feet, descend to 10,000 feet or the minimum safe altitude.

Known or suspected strike with landing gear extended or in takeoff or landing configuration with high lift deployed

- Use available system information to assess possible damage to flight controls and high lift devices, and make minimal and prudent changes in airplane configuration in accordance with the flight phase.
- Use available system information to assess possible damage to landing gear and associated systems, including exposed electrical, pneumatic, and hydraulic systems, and potential effects on the ability to steer and stop on the runway.

Known or suspected strikes to air data and angle-of-attack sensors

- Be aware that this may affect other airplane systems and have cascading effects.
- Be aware of the potential for loss or erroneous air data and degraded flight control modes, including loss of envelope protection or limiting, unreliable airspeed, propulsion systems in alternate mode.

Bird strikes during approach or landing

- If the landing is assured, continuing the approach to landing is the preferred option. If more birds are encountered, fly through the bird flock and land.
- Maintain as low a thrust setting as possible.
- If engine ingestion is suspected, limit reverse thrust on landing to the amount needed to stop on the runway. Reverse thrust may increase engine damage, especially when engine vibration or high exhaust gas temperature is indicated.

Postflight actions following a known or suspected bird strike

- Report all known or suspected bird strikes or bird activity on or in the vicinity of the airport via established procedures. Ideally this information reaches all stakeholders, including air traffic control, the airport operator, the airline, airplane and engine manufacturers (particularly the local representative), the national regulatory authority, and the appropriate national bird-strike committee or aviation wildlife hazard group.

Airport Bird Strike Mitigation Techniques

Why are the wildlife on the airport? Are they attracted to the airport for food, water, or shelter; or are they just flying over the airport from nighttime roosting sites to daytime feeding sites? The answer to this question will determine, to a large extent, the most appropriate control methods to use.

- Habitat features, including open areas of grass and water as well as shrubs and trees, provide food and roosting sites for birds. Even transient water accumulation on uneven pavements can be a significant bird attractant.
- Landfill and other waste disposal sites often attract large numbers of birds if they are not carefully managed.
- Some types of agricultural activity, on or in the vicinity of an airport, may attract birds.
- Migrating birds often follow well-defined flight paths in considerable numbers. This can create a hazard if the flight paths are near an airport.
- Airports in coastal locations often have a much higher level of un-managed bird activity than do inland airports.
- Most airports contain considerable areas of grass within their perimeters. Even dry grass can be attractive as a loitering area for birds by day or night.

The opportunities to mitigate the risk of hazardous bird strikes in the first place are centered on airports, because this is where the greatest overall volume of conflict occurs, and because this is where management and control of the hazard is most easily achieved. However, there are two problems with this approach:

1. The airport-centered bird strike risk is rarely confined to the perimeter of any particular airport
2. Many of the most hazardous strike encounters - those with large flocking birds - take place so far from the airport that the airport operating authority will often have little real influence over the circumstances.

Establishing and monitoring levels of bird activity is important and a critical part of this process is the recording of bird strikes at the local level. This then provides the opportunity to build up larger databases and to share the information. The analysis of bird/wildlife data in respect of bird strikes and observations and monitoring of bird/wildlife activities can reveal trends that will assist airport authorities to recognize areas of concern which should be addressed through a well-managed wildlife control program. Bird/wildlife strike statistics can also be analyzed to determine those times of year or day when bird/wildlife control is needed the most.

Airport Bird Strike Mitigation Techniques Cont...

Dedicated remote-sensing systems, primarily using bird detection radars, are in use and under development at a number of civil and military airports in several States. These systems provide real-time detection capability and can provide three-dimensional information on birds on and surrounding airports. Other systems, such as infrared and satellite imagery, can potentially provide similar detection capabilities.

Because of the importance of bird/wildlife control, each airport operator has the responsibility to develop, implement and demonstrate an effective bird/wildlife strike and wildlife control program at the airport, and this should be tailored to and commensurate with the size and level of complexity of the airport, taking account of the identification of the bird hazard and the risk assessment of that hazard.

Airports should also liaison with planning and zoning agencies to help influence land use decisions on and off the airport where they may increase the hazard to aircraft. It has long been recognized that land use around the airport can influence bird and other wildlife strikes to aircraft. Birds/wildlife can be attracted to areas near the airport and in turn go to the airport for food, water, resting or shelter. Some birds may also be struck outside airport property, over a land use that attracts them. When considering proposed land uses, operators and sponsors of airports certificated under Part 139, local planners, and developers must take into account whether the proposed land uses, including new development projects, will increase wildlife hazards. Land-use practices that attract or sustain hazardous wildlife populations on or near airports can significantly increase the potential for wildlife strikes. To successfully deal with land-use issues, a comprehensive wildlife management plan including coordination among the aviation regulatory authority, airport operator, aircraft operators and the surrounding communities should be implemented.

Birds and other wildlife on, and in the vicinity of, the airport may represent a threat to aircraft safety. In some cases, this threat can be reduced by adapting the aircraft's schedule in favor of the wildlife, especially when the presence of wildlife is for a limited time. Reducing the presence of wildlife in aircraft flight paths can be achieved through ecological means such as habitat management or the dispersal or removal of hazardous wildlife. While the wildlife control program will be airport-specific, the development of such nature and environmentally sensitive program should adhere to national environmental regulations.

Generally, there are tools and techniques available to manage wildlife hazards associated with airports at an acceptable risk level. Four basic control strategies are available to solve wildlife problems on airports:

1. Aircraft flight schedule modification;
2. Habitat modification and exclusion;
3. Repellent and harassment techniques; and
4. Wildlife removal.

Airport Bird Strike Mitigation Techniques Cont...

Plane Schedules

Learning to work with the birds by modifying flight paths and schedules can help minimize bird strikes. While these methods may not be feasible at all airports, they can be used to help the airport work in harmony with the wildlife surrounding it.

- Training spotters with binoculars and scopes to pinpoint hazardous birds and directing planes to different runways or approaches
- Using radar equipment to track the movement and density of bird flocks to predict their behavior and manage control techniques more effectively
- Adjusting flight times to avoid the busiest hours for bird activity, such as early morning and late evening or during peak migration periods

Habitat

Habitat modification means changing the environment to make it less attractive or inaccessible to birds is an easy way to encourage wild birds to seek alternative roosting and feeding grounds. All wildlife require food, cover, and water to survive. Any action that reduces, eliminates, or excludes one or more of these elements will result in a proportional reduction in the wildlife population at the airport. Habitat modifications to make the airport and surrounding area as unattractive as possible to hazardous wildlife must be the foundation of every airport's Wildlife Hazard Management Plan.

Effective measures include:

- Airports should systematically review features on, and in the vicinity of, the airport that attract birds/wildlife. A management plan should be developed to reduce the attractiveness of these features and to decrease the number of hazardous birds/wildlife present or to deny them physical access to these areas.
- Be aware of food attractants for birds that exist on and in proximity to the airport.
    - Some of the more common urban food sources for birds on and near airports include handouts from people, grain elevators, feed mills, sewer treatment plants, and improperly stored food waste around grocery stores, restaurants, and catering services.
        - On the airport, require bird-proof storage of food waste, prohibit bird feeding, and promote good sanitation and litter control programs.
    - Rural food sources attractive to birds include sanitary landfills, feedlots, certain agricultural crops (especially cereal grains and sunflower), and spilled grain along road and railways.

Airport Bird Strike Mitigation Techniques Cont...

- Removing seed-bearing plants to eliminate food sources
- A promising approach to reducing wildlife attraction to airport ground cover, irrespective of the height, is the use of vegetation that is undesirable or mildly toxic to wildlife
- Agricultural crops, where possible, should be discouraged from the airfield environment since agricultural crops and related activities (ploughing, mowing) will provide food for hazardous birds/wildlife.
- Do not use trees and other landscaping plants for the street side of airports that produce fruits or seeds attractive to birds
- Remove all unnecessary posts, fences, and other structures that can be used as perches by raptors and other birds.
- Using insecticides or pesticides to eliminate food sources for insect-eating birds
- Removing brush and trees that serve as attractive nesting sites
- Aerodrome grass management appropriate to the prevalent species and the degree of risk that they pose. Grass height maintenance can be very important. Vegetation composition (grass) should be kept at a height that is considered unattractive to hazardous birds/wildlife, while accepting that this may not be applicable in arid locations. The attractiveness of vegetation is a balance between food presence, food accessibility and protection against predators.
- Avoid the creation of areas of dense cover for roosting
    - Thinning the canopy of trees, or selectively removing trees to increase their spacing, can help eliminate bird roosts that form in trees on airports.
- Adjustments in mowing schedules (e.g., mowing at night to minimize bird feeding on insects exposed by the mowing)
- Water acts as a magnet for birds; therefore, eliminate all standing water on an airport to the greatest extent possible.
- Do not establish retention ponds, open drainage ditches, outdoor fountains and other wetland sites on or adjacent to airports.
- Use physical barriers, such as bird balls, wires grids, pillows, or netting, to deter birds from nearby ponds.
    - Evaluate the use of physical barriers and ensure they will not adversely affect water rescue.
- Encourage off-airport storm water treatment facility operators to incorporate appropriate wildlife hazard mitigation techniques into their operating practices.

Airport Bird Strike Mitigation Techniques Cont...

- Liaison with local authorities to ensure that waste water and landfill waste disposal sites are not operated near the airport so as to create an aircraft hazard.
- Liaison with local farmers to limit the attraction of birds to fields.
- Architects should consult biologists during the design phase of buildings, hangers, bridges, and other structures at airports to minimize exposed areas that birds can use for perching and nesting.
- Anti-perching devices, such as spikes, can be installed on ledges, roof peaks, rafters, signs, posts, and other roosting and perching areas to keep certain birds from using them.

Repellent Techniques

Repellent and harassment techniques are designed to make the area or resource desired by wildlife unattractive or to make the wildlife uncomfortable or fearful. Repellents work by affecting the animal's senses through chemical, auditory, or visual means. Critical factors to be recognized in deploying repellents are:

1. There are no "silver bullets" that will solve all problems;
2. Likewise, there is no standard protocol or set of procedures that is best for all situations. Repelling wildlife is an art as much as a science. The most important factor is having motivated, trained, appropriately equipped personnel who understand the wildlife situation on their airport;
3. Each wildlife species is unique and will often respond differently to various repellent techniques. Even within a group of closely related species, such as gulls, the various species will often respond differently to various repellent techniques; and
4. Habituation to repellent techniques can be minimized by
    A. using each technique sparingly and appropriately when the target wildlife is present,
    B. using a variety of repellent techniques in an integrated fashion, and
    C. reinforcing repellents with occasional lethal control (with necessary permits in place) directed at abundant problem species such as gulls or geese.

Advances in electronics, remote sensing capabilities, and computers are resulting in the development of "intelligent" systems that can automatically deploy repellent devices (e.g., noisemakers, chemical sprays) when targeted wildlife enter a designated area. These devices might help reduce habituation and increase effectiveness of repellents in some situations. However, these devices will never replace the need for trained people on the ground to respond appropriately to incursions by a variety of highly adaptable, sentient wildlife species.

Airport Bird Strike Mitigation Techniques Cont...

Several methods can be used to modify birds' behavior, so they will not stay near an airport. These techniques do not harm the birds but encourage them to avoid the region.

- Wildlife patrols and runway sweeps in vehicles are a critical component of an integrated program of wildlife hazard management on airports.
    - Often, driving a vehicle toward the wildlife will be enough to cause the wildlife to disperse.
    - Regular patrols and sweeps also permit wildlife control personnel to learn the daily movement patterns, habitat preferences, and behavior of wildlife on the airport. This information can be useful in determining wildlife attractants on the airport that need to be removed (e.g., low areas that gather standing water after rains) and in anticipating problem situations.
- Chemical Repellents
    - Perching structures (polybutenes). Several commercial products are available in liquid or paste form. These sticky formulations make birds uncomfortable when they alight on them, encouraging the birds to look elsewhere to perch or roost.
    - Turf feeding (methyl anthranilate, anthraquinone). The chemicals act as a conditioned-aversion repellent with birds. Using sonic cannons, recorded predator calls, and other noise generators to disrupt birds
    - Water (methyl anthanilate). Methyl anthranilate formulations are also available for application to pools of standing water on airports and at other locations to repel birds from drinking and bathing.
    - General area (fogging with methyl anthanilate). A methyl anthranilate formulation is also available for use in fogging machines (thermal or mechanical) to disperse birds from hangers, lawns, and other areas.
    - Frightening agent (Avitrol [4-Aminopyridine]). Birds eating Avitrol-treated baits react with distress symptoms and calls, behaviors that frighten away other birds in the flock.
- Audio Repellents
    - Propane cannons. Propane cannons (exploders) generate a shotgun-sounding blast.
        - Systems designed so cannons placed around an airport can be detonated remotely on demand by radio signal when birds are in the area are a useful means of reducing habituation.
    - Distress-call and electronic noise-generating systems. Recorded distress calls are available for common birds on airports, such as gulls, crows, and starlings. Such calls, broadcast from

Airport Bird Strike Mitigation Techniques Cont...

speakers mounted on a vehicle, will often initially draw the birds toward the sound source to investigate the threat. The birds then can be dispersed by pyrotechnics or by using a shotgun to shoot an occasional bird.

- Shell crackers and other pyrotechnics. There are a variety of projectiles that can be fired from breech-loaded shotguns or from specialized launchers to provide an auditory blast or scream, as well as smoke and flashing light, to frighten birds.

- Visual Repellents
  - In general, visual repellents, such as hawk effigies or silhouettes, eye-spot balloons, flags, and Mylar reflecting tapes, have shown only short-term effectiveness and are inappropriate for use as a long-term solution to bird problems on airports.
  - One visual deterrent that has been successfully used in recent years is the display of dead birds in a "death pose."
  - Using lasers at dawn and dusk to simulate predators and scare birds away
- Flying trained falcons over roosting areas to disrupt birds before they nest
- Training dogs to track through the habitat and teach birds that the area has many predators
- Radio-controlled (RC) model aircraft, which provide both visual and auditory stimuli, occasionally have been used to harass birds on airports and herd birds away from the runway(s).
- Paint balls and rubber or plastic projectiles, fired from paint-ball guns and 12-gauge shotguns, respectively, can be used to reinforce other dispersal techniques
- As a last resort, birds may be captured and relocated by authorized wildlife control officials if they cannot be encouraged to leave the area naturally. In extreme cases, birds may be culled with the proper authorization.

Wildlife Removal

In general, killing of wildlife on an airport is the last option deployed after habitat modification, exclusion techniques, and repellent actions have been implemented. However, the management of a wildlife hazard situation on an airport might require killing a particular animal or require that a local population of a problem species be reduced by lethal means until a long-term, nonlethal solution is implemented (e.g., relocation of nearby gull nesting colony). In addition, lethal control of a few individuals is sometimes necessary to reinforce nonlethal frightening techniques.

- Shooting birds.

Airport Bird Strike Mitigation Techniques Cont...

- Oral toxicants
- Contact toxicants

Habitat modifications to minimize food, cover, and water and physical barriers to exclude wildlife are the foundations of wildlife hazard management programs for airports. In addition, an integrated array of repellent techniques is necessary to disrupt normal behavior and to stress hazardous wildlife that attempt to use the airport. Airports that are most successful at minimizing bird strikes have employed all four methods through various techniques. These repellent techniques must be used judiciously and backed by real threats to minimize habituation. To this end, lethal control of selected individuals of common species is sometimes necessary to reinforce repellent actions.

While there are many potential solutions and strategies available, not all are necessarily relevant to the particular circumstances of a specific airport. The most important action, upon which any risk management strategy must be founded, is knowing the nature of the (unmanaged) hazard. This may vary by time of day and seasonally and must be related to the likely pattern of aircraft movements. Once a risk management plan is in place, it must be recognized that it is still necessary to monitor proactively for any detectable change in the assumptions upon which the plan was based.

Appendix A

Active Wildlife Management Techniques

	Technique	Primary Targets	Potential Efficacy as Part of an Integrated Program
Non-lethal	Pyrotechnics	Birds, some mammals	High
	Gas cannons	Birds, especially migrants	Moderate
	Report Shells	Soaring birds (e.g., gulls)	High
	Lasers	Birds, especially roosting	Moderate
	Falconry	Birds	High
	Border Collies	Birds, some mammals	High to moderate
	Live trapping	Birds, some mammals	Low to moderate
	Chemical - irritants	Birds	Low
	Playback of distress calls - remote system	Birds	Low to moderate
	Playback - mobile	Birds	Moderate to high
	Flags	Birds	Low to moderate
	Dead specimen birds	Birds	Moderate
	Chemical - behavioural repellents	Birds, mammals (on cables)	Moderate
	Radio-controlled models	Birds	Low (can be higher)
Lethal	Lethal trapping	Small mammals	Low
	Chemical - lethal control	Birds in buildings, mammals	High to moderate
	Chemical - Benomyl/Tersan fungicide	Fungus in turf but kills earthworms	Moderate
	Earthworm sweeping	Earthworms on hard surfaces	Moderate to high
	Surfactant water sprays	Roosting birds	Moderate
	Live-ammunition shooting	Birds, some mammals	High

Because wildlife species often habituate to non-lethal threats within a few weeks, in the long-term, dispersal techniques are seldom effective unless a clear and present danger is presented to the target species (e.g., with a dog, raptor or live gunshot). The management challenge is to keep wildlife guessing when the threat is real, and when it is not.

Appendix B

Passive Wildlife Management Techniques

These techniques are generally those that alter habitat or permanently exclude entry. Experienced wildlife managers know very well that measures to deter or exclude one species (e.g., short grass) will inevitably attract another species. There is an overriding principle that should be followed with habitat alteration: the minimization of habitat diversity. More diverse habitat means more diverse wildlife species. Managing one particular group of wildlife species can be easier than addressing a mosaic of species attracted by a variety of habitats through the seasons.

Examples	Suggested Approaches (see Wildlife Control Procedures Manual for more details)
Cropland	• Generally none within 365 m of a runway • Limit to: hay, alfalfa, flax, soy, fall rye, wheat, barley and other cereals, not corn or oats • Avoid ploughing - require night-time ploughing, haying; other harvesting controls and no standing bales
Grass	• Manage height according to hazards at the airport • Adaptive management, experimental manipulation at individual airports • Avoid allowing grass to set seed, seed-head suppression
Buildings	• Ensure entry holes/crevices blocked, screened, netting • Influence design of new buildings, slope ledges • Porcupine wire, electric shocking, sticky caulking
Open water, ponds, ditches, stormwater ponds, poorly drained areas	• Drain, improve drainage • Fill, over-wire, netting, BirdBallsT • Grade slopes steeply, remove vegetation • Trap mammals (e.g., American Beaver and Muskrat)
Shrubs, trees, brush, hedges, woodland	• Remove, including undergrowth and understorey layers • Reduce biodiversity, habitat niches
Infield perching features	• Remove • Apply spikes when required
Waste storage	• All disposal containers must be wildlife proof • Eliminate dumps on the airport
Outdoor picnic areas	• Signage • Provide wildlife proof garbage containers
All remaining habitats, airport perimeter	• Chain-link fencing, high-tensile fixed knot fencing, • ElectroBraidT fencing, • Buried fences • One-way gates, cattle gates.
Aircraft	• Ensure that bird nesting does not occur within parked aircraft, generally from April 01 to July 30 in Canada.